Lacamas Lake Watershed Water Quality Monitoring Program
Quality Assurance Project Plan

Project Title:	Lacamas Lake Watershed Water Quality Monitoring Program
Lead Organization:	Clark County Department of Public Works Environmental Services Division, Watershed Resources Section
Funding Source:	Washington Department of Ecology, Centennial Clean Water Fund
Grant Number:	TAX 90024
Project Coordinator:	Robert Hutton, Clark County

Approved:_____ Date:_____
Department of Ecology

Approved:_____ Date:_____
Robert Hutton, Program Manager
Lacamas Lake Restoration Program

Prepared by: Robert Hutton, Program Manager
Lacamas Lake Restoration Program

Jeff Schnabel, Field Coordinator
Lacamas Lake Restoration Program

TABLE OF CONTENTS

Lacamas Lake Watershed Water Quality Monitoring Program Quality Assurance Project Plan

1.0 Project Description

1.1 Historical Information

Lacamas and Round Lakes are located in Clark County, Washington, approximately two miles north of the city of Camas. The watershed of these lakes covers approximately 41,000 acres and their combined surface area is 315 acres. The lakes are an important recreational attraction and also provide water for industrial use at a paper mill in Camas.

Periodic water quality monitoring by the Southwest Washington Health District (SWHD) from 1974-1980 raised concerns about water quality problems in Lacamas Lake and its tributary streams. By 1983, the Clark County Intergovernmental Resource Center (IRC) received a Washington Department of Ecology (DOE) grant to fund a Phase I Diagnostic and Restoration Analysis. That study, the first comprehensive evaluation of water quality conditions in the watershed, concluded that the lake suffers from severe eutrophication due to nutrient loading from the watershed. Water quality problems in the lake include dissolved oxygen depletion, poor water clarity, high levels of algal growth, nuisance blue-green algal blooms, and dense stands of aquatic macrophytes.

Subsequently, the Lacamas Lake Restoration Program (LLRP), funded in part by a DOE Centennial Clean Water Fund grant, has pursued a program of agricultural Best Management Practice (BMP) implementation, water quality monitoring, and public education in the watershed. Water quality investigations have been and continue to be an integral component of LLRP activities. LLRP staff conducted an ambient water quality monitoring program in the watershed during 1991 and 1992. More recently, the program contracted with E&S Environmental Chemistry, Inc. to perform additional ambient monitoring and several specialized water quality investigations during 1995-1997. These monitoring activities confirmed that Lacamas Lake continues to exhibit eutrophic conditions. Results of the specialized investigations are being used to evaluate nutrient dynamics in order to maximize the efficiency of lake management and restoration efforts.

The LLRP contract with E&S Environmental Chemistry ends in December 1997. LLRP staff intend to continue focused ambient water quality monitoring activities and pursue several additional specialized investigations which were delayed during 1997. Much of this QAPP is based on a previously DOE-approved QAPP developed by E&S Environmental Chemistry, Inc. for the LLRP (Raymond, 1995).

1.2 Goals and Objectives

The overall goals of this Lacamas Lake Watershed Water Quality Monitoring Program are to:

1) Collect representative data to describe the general ambient water quality status of Lacamas Lake and its major tributaries.

2) Utilize special studies to provide decision-makers with more complete information on the nature of pollutant loading to Lacamas Creek and Lacamas Lake.

Pursuant to these goals, it is the intent of this program to provide data which is scientifically valid, consistent, and comparable with previous data collected from the lake and its watershed. The program includes sample collection and field measurements at selected stations, laboratory analysis of samples, database management and analysis, and a brief final report.

Specific objectives of the program are to:

1) Update and supplement the existing stream discharge rating curve for Lacamas Creek at Goodwin Road.

2) Assess the effects of storm event runoff on water quality in Lacamas Creek

3) Calculate estimated pollutant loads to Lacamas Lake

4) Collect data on long-term ambient water quality in Lacamas Lake

5) Better define the sources and extent of nitrate inputs to Lacamas Creek

6) Perform limited biomonitoring of tributary streams

1.3 Site Description

The project site is the Lacamas Lake watershed, located in Clark County, Washington (Figure 1). The site includes Lacamas Lake, Round Lake, Lacamas Creek, and tributaries to Lacamas Creek.

Figure 1 shows the locations of sampling stations for each component of the Program. Data pertaining to objectives 1-3 will be collected from Lacamas Creek immediately upstream of Goodwin Road (station A1). A single in-lake station will provide data to meet objective 4 (station L1). Data for objective 5 will be collected from multiple stations along the lower portion of the main stem of Lacamas Creek (Station N1-N10). Station A1 and station L1 correspond to the historical location of these sampling stations from previous monitoring efforts. Exact locations of sampling stations N1-N10 along the main stem of Lacamas Creek will be based on accessibility, landowner cooperation, and information contained in earlier studies. Up to six stations will be sampled for objective 6. Priority locations for the lower watershed stations (B1-B5) will correspond to the historical location of ambient water quality monitoring stations A1-A5. One reference station (B6) will be added in the upper watershed to serve as an indicator of "least disturbed" conditions.

1.4 Schedule

Sampling will commence in early 1998. The interval between samples at the in-lake station (L1) will be variable between 20 and 40 days to avoid the influence of possible cyclic patterns in water quality. Storm-event sampling will be spaced throughout the year in order to capture data during various streamflow and watershed conditions.
Sampling for nitrate along the main stem of Lacamas Creek will occur on two occasions, one during high flow (winter) conditions and the other during low flow (summer) conditions.
Biomonitoring will take place on two occasions, once in the late spring and again in the early fall.

All water samples will be either hand-delivered to the laboratory, picked up by laboratory personnel, or properly packed and shipped to the laboratory on the same day they are collected. Standard chain of custody procedures will be followed. Analytical results will be provided within three weeks of receipt of the samples.

2.0 Project Organization

The LLRP is administered through the Clark County Public Works Department, Environmental Services Division. The Program described in this QAPP will be carried out by LLRP staff under the supervision of the Clark County Department of Public Works.

Brian Carlson is the Environmental Services Division manager, and Earl Rowell is the immediate supervisor of LLRP staff. Robert Hutton is the LLRP Program Manager and Jeff Schnabel is the LLRP Field Coordinator. The Program Manager is responsible for organizing, coordinating, and administering all LLRP activities. The Field Coordinator oversees all field activities for the LLRP and will be responsible for the execution of the water quality monitoring program in accordance with the procedures outlined in this QAPP.

The Field Coordinator and other trained LLRP staff will conduct all field sampling and collect all field measurements. Staff members involved in the project will be trained by the Field Coordinator to properly collect, preserve, label, store, and transport or ship field samples to the lab for analysis.

All laboratory analyses for the Program will be performed by North Creek Analytical (NCA), a DOE accredited laboratory located in Beaverton, Oregon. NCA will be responsible for conducting all laboratory analyses in accordance with the NCA Quality Assurance Program (Appendix F). The LLRP Field Coordinator will review the analytical data for compliance with QA/QC criteria. Data analysis, interpretation of results, and writing of the final report will be performed by LLRP staff.

3.0 Data Quality Objectives

The overall quality assurance objectives for the program are to implement quality control requirements for field work and laboratory analyses that will provide data that can be used to meet the program objectives, and to follow procedures that will provide data of known quality in terms of precision, accuracy, completeness, representativeness, and comparability. Quality assurance objectives are listed in Table 1.

3.1 Precision and Bias

The goal of the program is to establish an overall sampling precision of 20 percent relative percent difference. Methods of collection, preservation, transportation, and storage of samples have been designed following established procedures to reduce most sources of bias. The goal of the program is to maintain overall bias for each parameter lower than the levels listed in the DOE QA Plan Guidelines (Appendix D).

3.2 Representativeness and Completeness

The sampling program has been designed to be representative of the water quality conditions in the watershed at the time of sampling. There are no known constraints that would adversely affect the representativeness of the samples. Collection of samples at the same time of day on different sampling dates may have the potential to introduce some bias, but this is offset by the reduction in variability achieved using this method.

There are no known factors which would adversely affect the collection of complete data according to the sampling plan.

3.3 Comparability

Comparability of data collected during this program to other data is addressed by specifying standard methods and procedures for the collection and analysis of samples. Data collected during 1998 will be incorporated into the existing water quality database for the Lacamas Lake Restoration Program.

Table 1. Quality Assurance Objectives for the Lacamas Lake Watershed Water Quality Monitoring Program.

Constituent	Method	Target Detection Limit	Precision	Accuracy	Completeness
Ammonia	EPA 350.3	0.01 mg/L	20% RPD[1]	75-125%[2]	95%
Chloride	EPA 300.0 A	0.1 mg/L	20% RPD	75-125%	95%
Fecal coliform	APHA 9221 E	1/200 ml	na	75-125%	95%
Kjeldahl Nitrogen	EPA 351.4	0.01 mg/L	20% RPD	75-125%	95%
NO_3+NO_2	EPA 353.1	0.01 mg/L	20% RPD	75-125%	95%
Orthophosphorus	EPA 300.0 A	0.01 mg/L	20% RPD	75-125%	95%
Suspended solids	EPA 160.2	na	20% RPD	75-125%	95%
Total phosphorus	EPA 200.7/6010A	0.01 mg/L	20% RPD	75-125%	95%

[1]RPD = relative percent difference

[2]Acceptable range of spike recovery

4.0 Sampling Procedures

All sampling, analysis, and data management procedures will be conducted according to guidelines established or referenced in this QAPP, Standard Methods (APHA, 1992), and the contract between Clark County and NCA.

4.1. Sample Custody and Documentation

All sample collection will be conducted by LLRP staff or persons authorized by the Field Coordinator. Water samples will be collected in properly cleaned bottles which have been pre-labeled with indelible ink. Sample bottles will be provided by NCA. Sample identification will include: the letters "LL" to designate Lacamas Lake; date; station; depth (if applicable) and; parameter. Formal Chain of Custody documentation will be maintained by NCA in accordance with their Quality Assurance Program. Additionally, Lacamas staff will maintain sample tracking sheets (Appendix A). A Field Log will be maintained for all sampling, including sample location, name of sampler, date, time, weather conditions, streamflow measurements (if applicable), instrument calibrations, results of all field measurements, number and type of samples collected, and parameters to be analyzed. Any unusual conditions, observations, or deviations from normal procedures will also be recorded in the Field Log. Examples of lake and stream field log data sheets are included in Appendix C.

Information control procedures will include:

Records will be clear, comprehensive, and written in indelible ink.

Corrections to data sheets and logs will be made by drawing a single line through the error and initialing and dating the correction.

Records will be cross-checked for consistency between labels, custody documents, data sheets, field logs, instrument logs, and other relevant data.

Documentation will be archived in LLRP files.

4.2 Stream discharge rating curve (Objective 1)

Cross-sectional measurements of discharge will be collected on at least six occasions by measuring stream velocity and depth at approximately 20 locations across the stream channel during various stream stage conditions. Measurements will be taken from Lacamas Creek just upstream of Goodwin Road, at station A1. The current-meter equipment will be calibrated immediately prior to each sampling occasion. A discharge rating curve will be developed using standard current-meter methodology (Juul, 1997; Rantz et al., 1982). Instantaneous discharge will be plotted for the various stream stages to yield a discharge curve and predictive equation specific to station A1. This curve and equation will then be programmed into the automated monitoring equipment housed at station A1 to yield continuous discharge estimates.

4.3 Storm-event monitoring (Objective 2 and Objective 3)

An automated water quality sampling station has been installed by the LLRP on Lacamas Creek just upstream of Goodwin Road (Station A1). Approximately five to eight storm events will be sampled during 1998 using this equipment. For these purposes, a storm event will be defined as

rainfall exceeding one inch per 36 hour period forecasted by the National Weather Service in Portland, OR. Initially, ten to fifteen water samples will be collected per storm event, six to nine on the rising limb and four to six on the descending limb of the hydrograph. The number of samples per storm may be revised based on the initial samples. Three samples per storm event will also be collected from the outlet of Lacamas Lake, one each at the beginning, near the middle, and at the end of the storm. Data from these samples will provide information on the retention of pollutants within Lacamas Lake. Focused sampling of storm runoff and ambient conditions in selected subwatersheds may be undertaken in addition to the storm sampling at station A1. This monitoring will primarily utilize hand-held meters, with limited laboratory analyses for nutrients or other constituents. Samples will also be collected using the automated sampler on two occasions during non-storm conditions for comparison with the storm-event data. Non-storm condition samples will be collected between July and September when base-flows are lowest.

All samples will be analyzed at NCA for total phosphorus, orthophosphorus, total suspended solids, chloride, kjeldahl nitrogen, ammonia, and nitrate. Samples from up to five storm events will be analyzed for fecal coliform. Field measurements will include continuous monitoring of conductivity, pH, dissolved oxygen, and temperature using the automated monitoring equipment.

Data from the storm samples and automated monitoring station will be stored in digital database files and used to calculate estimated pollutant loading to Lacamas Lake. Approximate annual pollutant loads will be extrapolated from these short-term loading estimates.

4.4 Ambient in-lake monitoring (Objective 4)

Water samples will be collected approximately monthly from March-December from station L1 in the deepest area of Lacamas Lake. Sample depths will be approximately 1m, 6m, and 15m. Samples will be analyzed at NCA for total phosphorus, orthophosphorus, total suspended solids, Kjeldahl nitrogen, ammonia, and nitrate. Vertical profile measurements for temperature, pH, conductivity, and dissolved oxygen will be taken at 1m intervals at station L1 on each sampling date. Additional profiles may be taken at selected sites throughout the lake on some sampling occasions, especially during stratified conditions. Secchi disk readings will be taken at all locations where vertical profile data is collected. Ambient monitoring data will be added to the existing Lacamas Lake water quality database for the purpose of long-term trend detection.

4.5 Nitrate inputs to Lacamas Creek (Objective 5)

A longitudinal survey of the main stem of Lacamas Creek between Goodwin Road and its confluence with Fifth Plain Creek, as well as the lower section of Fifth Plain Creek (between Lacamas Creek confluence and China Ditch confluence) will be conducted to measure conductivity, temperature, pH, and dissolved oxygen. Measurements will be taken using properly calibrated portable water quality monitoring equipment. Water samples will be collected at approximately 10-15 locations and analyzed at NCA for nitrate-plus-nitrite nitrogen. Samples will be collected at fixed intervals and at locations where water quality measurements indicate that an abrupt change has occurred. The survey will be conducted twice to assess the effects of different precipitation and flow conditions.

4.6 Biomonitoring

Benthic invertebrates will be evaluated at several sites in the watershed using methods based on Rapid Bioassessment Protocol III (Plafkin, et al. 1989). Sample collection and analysis will be performed according to the methods described in Appendix E.

4.7 Standard Operating Procedures

The following standard operating procedures will be followed to maintain consistency in field methods:

1) In-lake samples will be collected with a VanDorn type sampler. Sample bottles will be rinsed two times with the sample water prior to filling.

2) Stream samples will be collected at approximately 60 percent of water depth in an area of maximum turbulence near the center of the stream. Samples will be hand-dipped by wading in the stream if possible, or by the use of a long-handled dipper. Sample bottles will be rinsed two times with the sample water prior to filling. Samples will be collected from upstream of the individual if wading.

3) Proper preservatives, as supplied by the laboratory, will be added to the samples in the field.

4) All samples will be stored on ice in the dark until delivery to the laboratory. The refrigerated automatic sampler will maintain water samples at 4^{o} C until pick-up and delivery to the laboratory in insulated coolers.

6) Secchi disk readings will be taken from the shady side of the boat to minimize glare. Eye-level for the readings will be just above the side of the boat.

4.8 Summary

The components of the sampling program are summarized in Table 2.

5.0 Analytical Procedures

All laboratory analyses will be conducted by NCA of Beaverton, Oregon, a Washington DOE accredited laboratory. All procedures will be performed according to the laboratory's quality assurance program and according to accepted conventions for data manipulation and reporting as described in Standard Methods (APHA, 1992). To maintain consistency with earlier data reported for the LLRP, analytical results will be reported as the actual value obtained, not as censored data (ie. "less than" values). This may result in some values being reported that are less than the laboratory's stated reporting limits, but will allow more robust statistical analysis of the data.

Table 3 shows the constituents measured, analytical methods, and reporting limits.

Table 3. Analytical Methods for the Lacamas Lake Watershed Water Quality Monitoring Program

Constituent	Units	Method	Reporting Limit
Ammonia	ppm as N	EPA 350.3	0.01mg/L
Chloride	ppm	EPA 300.0 A	0.1 mg/L
Fecal Coliform	MPN[1]	APHA 9221 E	<2/100 ml
Kjeldahl nitrogen	ppm as N	EPA 351.4	0.2 mg/L
Nitrate+Nitrite	ppm as N	EPA 353.1	0.01 mg/L
Orthophosphorus	ppm as P	EPA 300.0 A	0.01 mg/L
Total phosphorus	ppm as P	EPA 200.7/6010A	0.01 mg/L
Total suspended solids	ppm	EPA 160.2	5 mg/L

[1]MPN = most probable number

6.0 Data Reduction, Review, and Reporting

Laboratory data reduction, review, and reporting will be performed according to the NCA Quality Assurance Program. Data will be reported as hard copy delivered to the LLRP Field

Coordinator. Field data will be recorded in the field log book, examined for consistency and completeness, and reported. All data will be reviewed by LLRP staff and entered into a computer database compatible with Excel 5.0, consistent with the existing water quality database for the Lacamas Lake Restoration Program.

Brief annual reports for the program will include all data collected during the current year and a narrative summary of monitoring activities. Results will be interpreted in terms of water quality status and possible resource management implications.

A draft report of 1998 activities will be available for DOE review by April 1, 1999.

7.0 Quality Control Procedures

7.1 Field Data

Field instruments will be calibrated according to the manufacturer's instructions and checked using known check standards. One duplicate sample and one field blank (equipment blank using distilled water) will be collected for each sampling event and will be analyzed with the other samples from that event.

7.2 Laboratory data

Sample containers and holding times will conform to DOE guidelines as shown in Appendix B. Laboratory quality control will be according to standard operating procedures of NCA as described in their Quality Assurance Program. Quality control procedures will include check standards, matrix spikes, method blanks, split samples, and replicates as appropriate.

8.0 Data Assessment Procedures

Data will be assessed for their precision, accuracy, and completeness according to the methods described in the NCA Quality Assurance Program.

8.1 Precision

The relative percent difference (RPD) is used to assess the precision of the sampling and analytical methods. The RPD is calculated by the equation

$$RPD = (X_s - X_d)/[(X_s + X_d)/2] \times 100$$

where: X_s is the analytical result obtained for the sample, and
X_d is the analytical result, expressed in the same units, obtained for the duplicate sample

8.2 Accuracy

The accuracy of the data set is determined from the analysis of spiked samples. The accuracy (or percent recovery) is calculated using the equation

$$Accuracy = [(X_{ss} - X_s)/T] \times 100$$

where: X_{ss} is the analytical result for the spiked sample
X_s is the analytical result in the same units for the sample, and
T is the true value of the added spike

The overall accuracy is the arithmetic mean of accuracy calculated for all spiked samples.

8.3 Completeness

Completeness is defined as the percent of the total samples collected that produce acceptable data.

9.0 Corrective Action

If unacceptable conditions are discovered through review of field procedures or data, the Field Coordinator will be responsible for developing and initiating corrective action. Unacceptable conditions pertaining to analytical procedures will be handled in accordance with the NCA Quality Assurance Program. Corrective action could include re-analyzing samples (if quantity and holding-time criteria permit), re-sampling and re-analyzing, or evaluating and amending sampling and analytical procedures. Any final analytical results that do not meet the Data

Quality Objectives (section 3.0) will generally be rejected for use in calculations and data analyses. Any rejected results will be reported and flagged as rejected data.

Documentation of corrective action steps will include problem identification, investigation procedures, corrective action taken, and effectiveness of the corrective action.

REFERENCES

American Public Health Association. 1990. Standard Methods for the Examination of Water and Wastewater, 17th ed.

Gaddis, P. 1994. Clark County biological monitoring program: benthic invertebrates of the East Fork Lewis River, 1991 and 1992. Vancouver, WA: Clark County Department of Community Development, Water Quality Division.

Juul, S.T.J.. 1997. State of Washington Water Research Center, Pullman, Washington. Personal communication.

Plafkin, J.L., M.T. Barbour, K.D. Porter, S.K. Gross, and R.M. Hughes. 1989. Rapid Assessment Protocols for Use in Streams and Rivers. Macroinvertebrates and Fish. EPA 440-4-89-001. Office of Water, Regulations, and Standards, U.S. Environmental Protection Agency, Washington, D.C.

Rantz, E. S., and others. 1982. Measurement and computation of stream flow: Vols. 1 and 2. U.S. Geological Survey Water Supply Paper 2175.

Raymond, R. 1995. Lacamas Lake Watershed Water Quality Monitoring Program Quality Assurance Project Plan. E&S Environmental Chemistry, Inc., Corvallis, OR.

APPENDICES

Appendix E- Biomonitoring Procedures

(from Clark County Biological Monitoring Program: Benthic Invertebrates in the East Fork Lewis River, 1991-1992 by Philip Gaddis)

Sample Collection

Benthic invertebrate (bug) samples will be collected with a "D"-shaped dipnet measuring 1 foot wide x 1 foot tall, mounted on a 5-foot pole. The net will have a mesh size of 500 microns. To collect the samples, the net will be placed on the substrate, and all rocks over two inches in diameter upstream of the net in an area two net widths long will be rubbed clean by hand in such a way that any adhering bugs will be swept into the net by the current. The area upstream of the net will then be stirred up by kicking the substrate, dislodging burrowing organisms. The contents of the net will then be placed in a shallow 8 in. x 12 in. plastic pan. The process will be repeated until at least three samples or 100 specimens are collected.

A random sample of 100 specimens will be taken from the pan. The bugs and debris, with just enough water to cover them, will be mixed thoroughly, distributing them randomly throughout the pan. Starting on one side of the pan and proceeding in a straight line to the other side, all bugs in a two-inch path will be collected and counted. When the other side is reached, the remaining bugs and debris will again be thoroughly mixed and distributed. The process will be repeated until 100 specimens are removed from the pan. Bugs will be counted using a hand tally meter. Only live bugs will be collected. Empty snail shells and caddis fly cases will not be included since these cannot be used reliably to infer that the bugs that produced them are currently living at a site. The specimens will be placed in plastic sample bags containing 80% denatured alcohol for preservation.

Sample Analysis

Lacamas staff will identify the bugs in the laboratory using a binocular dissecting microscope with magnification of 7x to 45x. Identification will be to the lowest taxonomic level (usually genus) conveniently attainable by the non-expert. Insects will be identified according to Merritt and Cummins (1984).

The data will be analyzed in terms of community structure and pollution tolerance characteristics using the procedures followed in Gaddis (1994).

References

Gaddis, P. 1994. Clark county biological monitoring program: benthic invertebrates of the East Fork Lewis River, 1991 and 1992. Vancouver, WA: Clark County Department of Community Development, Water Quality Division.

Merrit, R.W. and K.W. Cummins. 1984. An Introduction to the Aquatic Insects of North America. Kendall/Hunt Publishing Company. Dubuque, Iowa. 2nd edition.